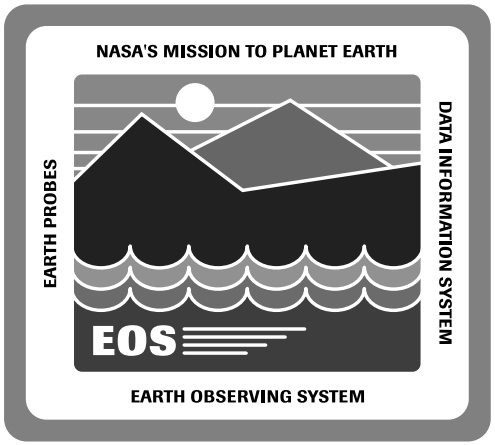
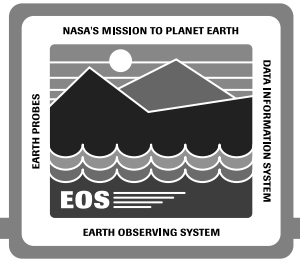


User and Algorithm Models

Andy Endal

14 February 1995

Topics



Boundary Conditions

Science User Model

- **Model components**
- **Derived parameters**
- **Design utilization**

Processing Scenarios

- **Ad Hoc Working Group on Production (AHWGP)**
- **New baseline and analysis**
- **Impact of changes since SDR**

System Performance Model

- **Model description**
- **Results**

Issues

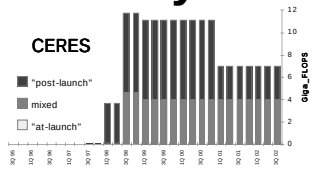
Modeling Context

Science User Model

Design Feedback

Request Profiles

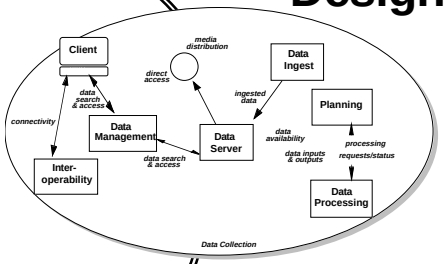
Modeling & Analysis



Resource Needs

Design Knowledge

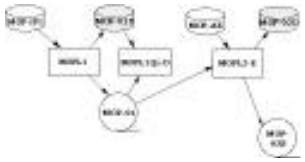
SDPS/CSMS Design



Processes, Files, Rules

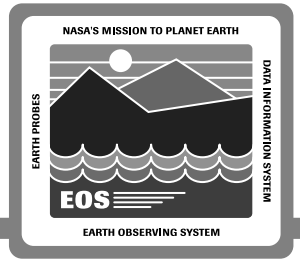
Feedback/ Validation

Processing Scenarios



Design Feedback

Boundary Conditions



Boundary Conditions Derive from Policy and/or Assumptions

1. User Community (policy)

- **User models describe the Earth Science / Global Change users**

2. Data Distribution (assumption / cost constraint)

- **Distribute data to the users at twice the rate of data production**
  - **50% electronic distribution; 50% by media**

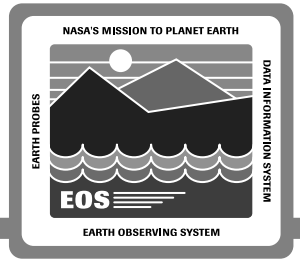
3. Data Processing (assumption / engineering parameter)

- **Peak processing capacity at least 4 times average requirement**

4. Data Reprocessing (assumption / engineering parameter)

- **Phased capacity starting with 0.3X (Launch - 2 years) for Algorithm Integration and Test**
- **Building to 4.2X (Launch + 2 years) to include reprocessing**

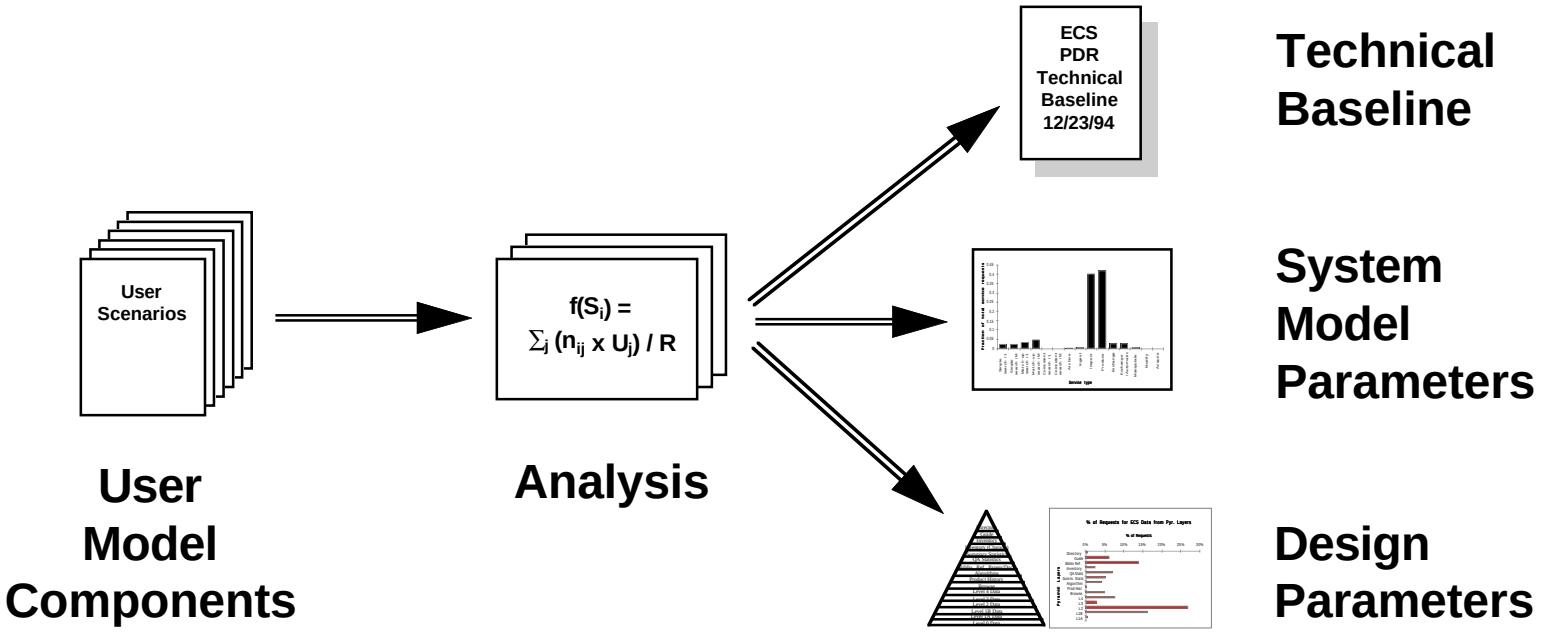
Boundary Conditions (cont.)



5. Data Archiving (assumption / engineering parameter)

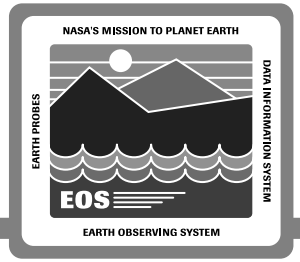
- **Archive Standard Product data (Levels 1-3)**
- **Twelve-month rolling archive for Level 0 data**
- **Retain Level 0 (after 12 months) only if no Level 1a product is available**
- **Capacity for six months of Standard Product data required to support reprocessing**

Science User Model



Current User Model is a Refinement of the SDR Model

User Model Components



Reference:

***ECS User Characterization Methodology and Results* (September 1994)**

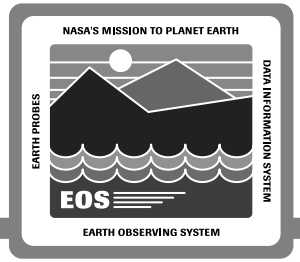
Science User Scenarios

- **Step-by-step description of system usage for science research**
  - **User request => Service invocation & data => results**
- **27 scenarios collected/validated during past twelve months**
- **Analyzed to extract relative frequency of service invocation in 15 categories (*e.g.*, single-site coincidence search, data inspection, ...)**

Science User Demographics

- **Utilized to assign number of users to each scenario**
- **Based on 1993 survey of articles in science research journals**

Model Components (cont.)



Relative Interest in Data Products

- **Five user disciplines (atmosphere, land & hydrology, oceans, cryosphere, interdisciplinary)**
- **Relative populations based on memberships in professional societies**
- **Used to size loads at specific DAACs and for specific servers**

Projected total number of user accesses per year

- **Based on statistics and projections from participating DAACs**
- **Independent estimates by B. Barkstrom (LaRC) and M. James (GSFC)**

Daily distribution of user accesses

- **September 1994 statistics from "killian" server at GSFC**

Geographic distribution of users

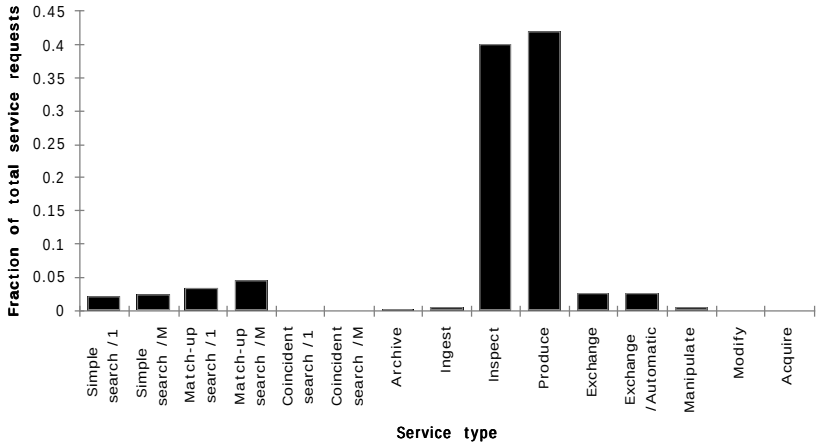
- **Distribution of EOS investigators, corrected for international users**

Analysis: Service Invocations

$$f(S_i) = \sum_j (n_{ij} \times U_j) / R$$

where:

- $f(S_i)$ = proportion of invocations for service S_i $[\sum_i f(S_i) = 1]$
- n_{ij} = number of times service S_i is invoked in scenario j (in 1 year)
- U_j = number of users associated with scenario j
- R = total rate of invocations of all services = $\sum_i \sum_j (n_{ij} \times U_j)$

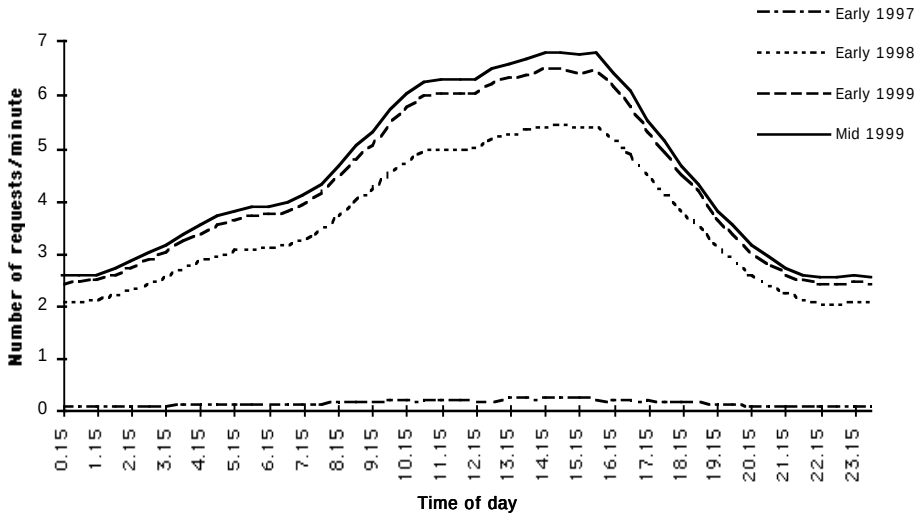


Analysis: Access Frequency

$$r(t_{EST}) = R \times \sum_K [f_K \, Ø(t_K + \Delta_{K->L})] / 525960 \text{ (min./yr.)}$$

where:

- $r(t_{EST})$ = rate of service invocation at Eastern Standard Time t_{EST}
- R = total rate of service invocation (see previous slide)
- f_K = fraction of users in time zone K
- $Ø(t_K)$ = fraction of service invocations originating at local time t_K
- $\Delta_{K->EST}$ = time difference from user zone K to EST



Analysis: Accesses by DAAC

$$P_L = P_{L@L} + \sum_{M \neq L} P_{M->L}$$

where:

P_L = service invocation probability at DAAC L

$P_{L@L}$ = probability user will access ECS through DAAC L and use local services

$P_{M->L}$ = probability of inter-DAAC service request from DAAC M to DAAC L

	Early 1997	Early 1998	Early 1999	Mid 1999
ASF	0	0.05	0.04	0.04
EDC	0	0.20	0.17	0.15
GSFC	0.44	0.19	0.22	0.24
JPL	0	0.12	0.12	0.12
LaRC	0.44	0.19	0.22	0.24
MSFC	0.12	0.20	0.17	0.15
NSIDC	0	0.05	0.04	0.04
Totals	1.00	1.00	1.00	1.00

Determined primarily by relative interest in data products (i.e., DAAC discipline and size of discipline community)

Design Utilization

Technical Baseline: For Each DAAC @ 5 Epochs

- **Archive Volume**
- **Volume Distributed**
- **Number of Users / Year**
- **Accesses / Year**

System Model Parameters

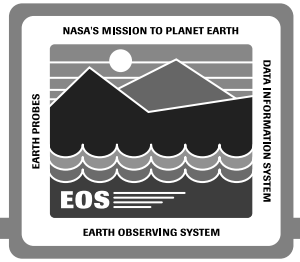
- **Distribution of requests by service type**
- **Access frequency by DAAC, and by time of day**

Design Parameters Developed at Request of Design Teams

- **Distribution of browse & subsetting requests by file size**
- **Request frequency by pyramid layer**
- **etc.**

End-to-end scenarios for design validation

Processing Scenarios



Current Model is a Major Departure from SDR

- **Processes and Physical Files**

Ad Hoc Working Group on Production (AHWGP)

- **Joint effort by Instrument Teams and ECS**
- **Covers Standard Product inputs, processing, outputs**
- **TRMM and EOS AM-1 instruments (ESC Release A and B)**

Information Provided by Instrument Software Teams

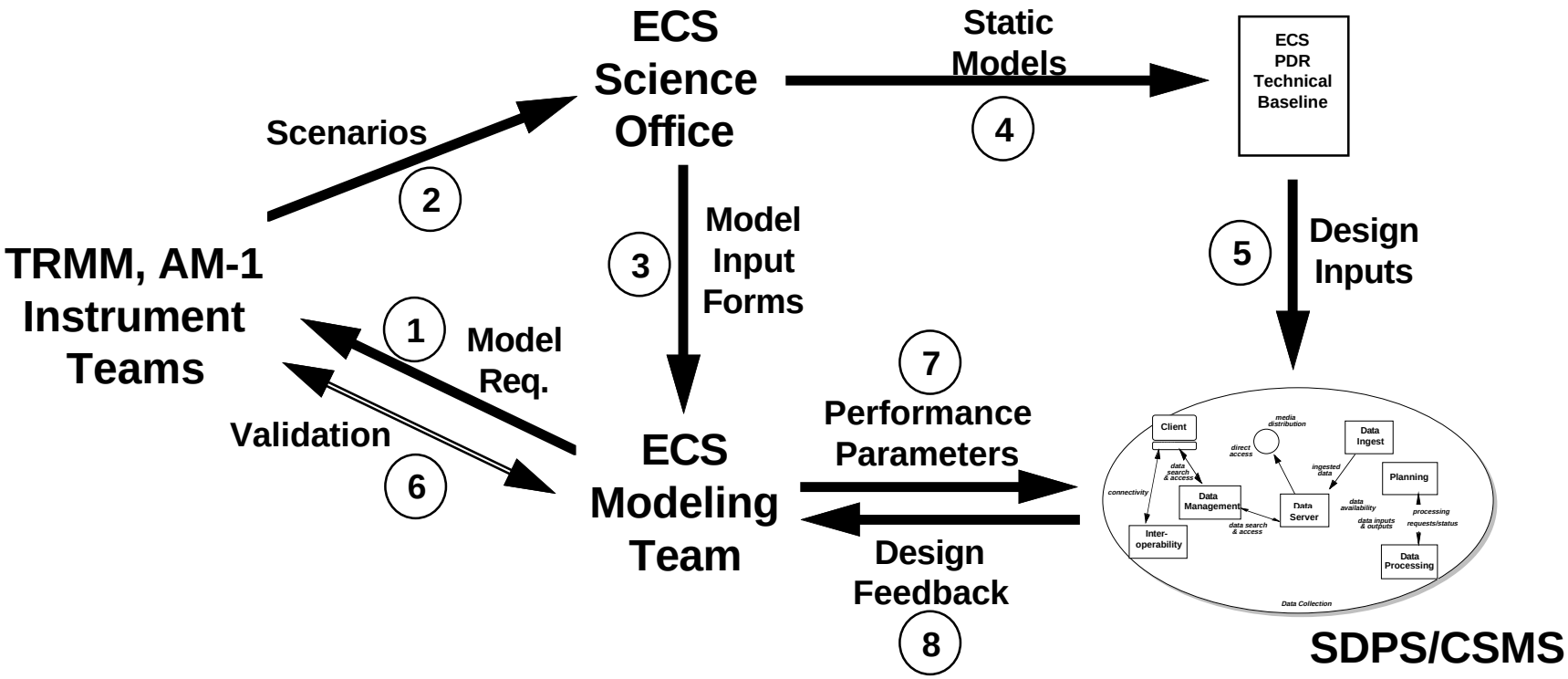
- **Designed to support ECS modeling requirements**

Static Models Used to Validate Inputs

- **Compared to SPSO database to flag changes for validation**
- **Provided to Instrument Teams to validate timelines**

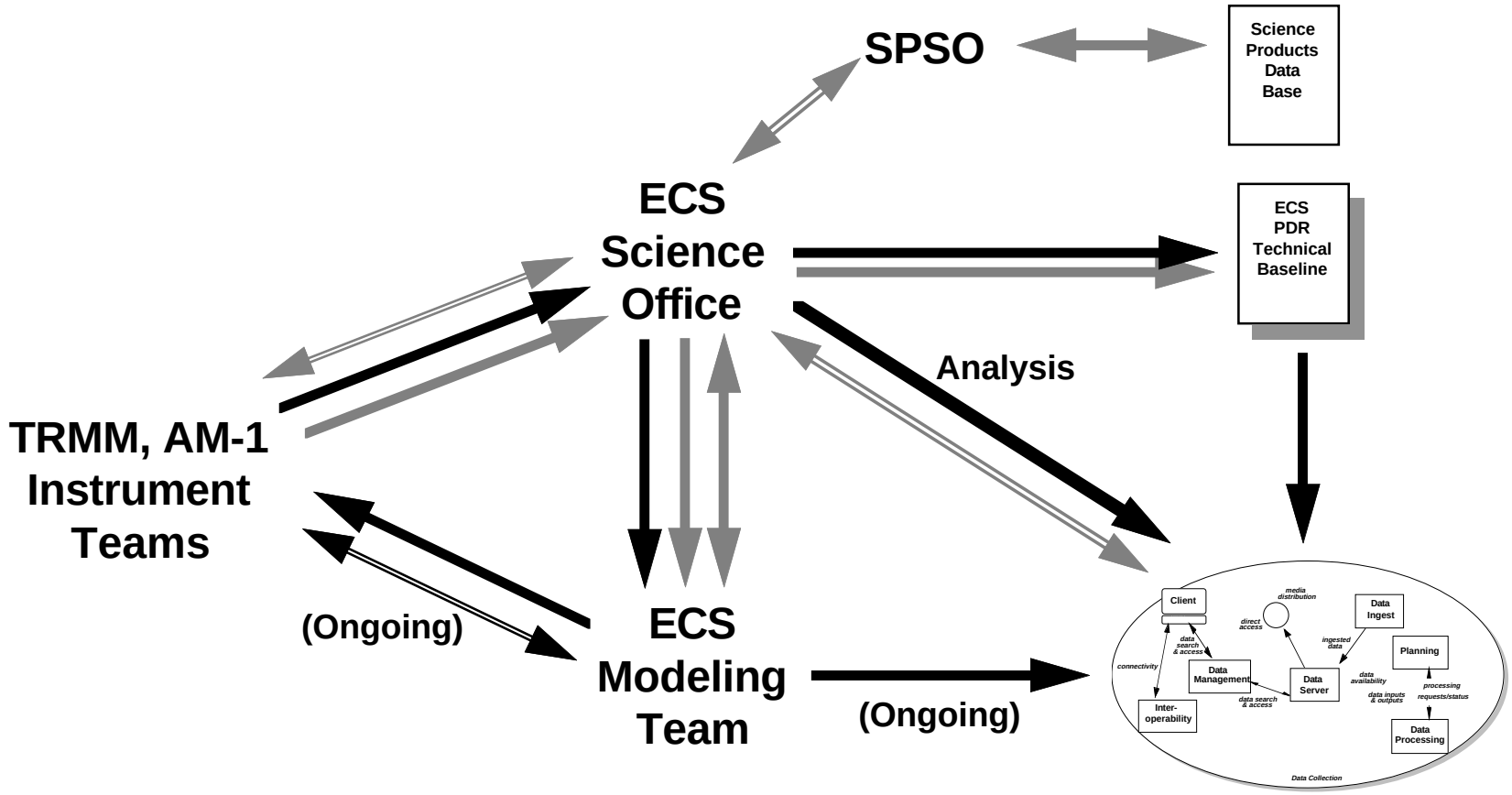
Dynamical Model Used to Identify Disconnects

AHWGP Process (linear)



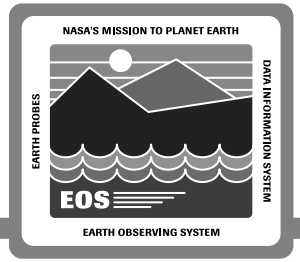
Validation Planned as Review of Models

AHWGP Process (actual)



Extensive Validation and Iteration at All Stages

Products Summary



Instrument Teams Inputs

- **Process Descriptions (production scenarios)**
- **File Descriptions (archive, permanent, interim, temporary)**
- **Process Phasing (time-line by calendar quarter)**

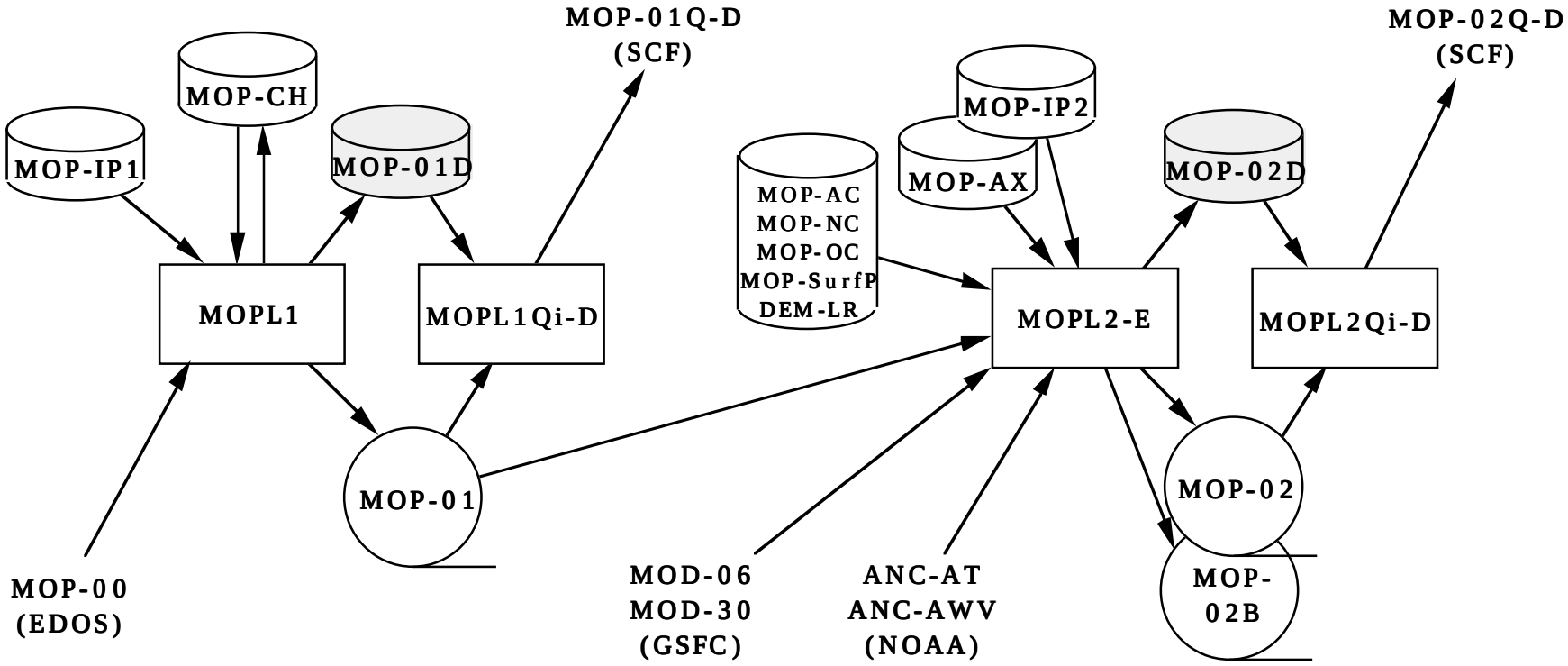
Converted to Tables for Model Ingest

- **XX Process Descriptions**
- **YY File Descriptions**

Analysis and Validation Based on Static Models

- **Processing Timelines (MFLOPS by quarter)**
- **Volume Timelines (GBytes / day by quarter)**
- **Total Processing / Reprocessing and Archive Requirements**
- **DAAC-to-DAAC Traffic for WAN Sizing (input to CSMS design)**

MOPITT Sample Scenario



MOPITT Daily Processing at 3Q 1999

= interim file

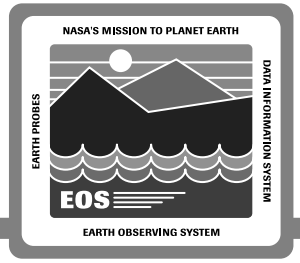
MOPITT Process Descriptions

Process ID	Process Name	Processing Site	Epochs	Input File IDs		Amount Read (Fraction)	Output File ID		Amt rtten (Fraction)	Millions of Floating Point Ops per E ecution	No. of E ec. /day
MOPL1	Level 1 Processing	LaRC	ghijklmnopqrstuvwx	MOP-00	1	1	MOP-01	1	1	16,800	1.00
				MOP-CH	1	1	MOP-01D	1	1		
				MOP-IP1	1	1	MOP-CH	1	1		
MOPL1Qi-D		LaRC	hijklmnopqrstuvwx	MOP-01	1	1	MOP-01Q-D	1	1	900	1.00
				MOP-01D	1	1					
MOPL2-E	Level 2 Processing	LaRC	jklmno	MOP-01	1	1	MOP-02	1	1	1,502,250	1.00
				MOP-IP2	1	1	MOP-02D	1	1		
				MOP-AX	1	1	MOP-02B	1	1		
				ANC_EDC_DEM	1	1					
				ANC_NMC_PROF	4	1					
				MOD30_L2_G	585	1					
				ANC_NMC_SURF	4	1					
				MOD06_L2_G	585	1					
				MOP-AC	1	1					
				MOP-SurfP	1	1					
				MOP-OC	1	1					
				MOP-NC	1	1					
MOPL2Qi-D	Level 2 QA (inline)	LaRC	jklmnopqrstuvwx	MOP-02	1	1	MOP-02Q-D	1	1	1,350	1.00
				MOP-02D	1	1					

MOPITT File Descriptions

File ID	Instrument	File Name		Archive Site		File Size (MB)	Temporal Coverage (Minutes)
MOP-00	MOPITT	MOPITT Level-0	MOP00	LaRC	Permanent	255.24	1,440.00
MOP-01	MOPITT	MOPITT Level-1	MOP01	LaRC	Archive	101	1,440.00
MOP-IP1	MOPITT			LaRC	Permanent	1	0.00
MOP-CH	MOPITT			LaRC	Permanent	1	43,200.00
MOP-01D	MOPITT			Other	Interim	255.24	0.00
MOP-01Q-D	MOPITT	Level-1 QA diagnostics		Other	Interim	10	0.00
MOP-IP2	MOPITT			LaRC	Permanent	1	0.00
MOP-AX	MOPITT			LaRC	Permanent	50	0.00
MOP-AC	MOPITT			LaRC	Permanent	1.4	0.00
MOP-OC	MOPITT	Ancillary Ozone Climatology		LaRC	Permanent	1.4	0.00
MOP-NC	MOPITT	Ancillary N20 Climatology		LaRC	Permanent	1.4	0.00
MOP-SurfP	MOPITT	Ancillary Surface Properties		LaRC	Permanent	5	0.00
MOP-02	MOPITT	MOPITT Level-2 product		LaRC	Archive	74.7	1,440.00
MOP-02D	MOPITT	Temporary diagnostic files		Other	Interim	100	0.00
MOP-02B	MOPITT	Level-2 Browse Products		LaRC	Archive	10	1,440.00
MOP-02Q-D	MOPITT	Level-2 QA diagnostic files		Other	Interim	10	0.00

MOPITT Scenario Comments



MOPITT Processing at LaRC

MODIS Products Transferred from GSFC to LaRC

- **MOPITT assumptions:**
  - **MOD-06 (atmospheric profiles) = 1 daily file of 140 MBytes (MB)**
  - **MOD-30 (cloud parameters) = 1 daily file of 100 MB**
- **MODIS plans for L2 products:**
  - **MOD06_L2 = 585 granules/day @ 17.52 MB = 10.2 GB / day**
  - **MOD30_L2 = 585 granules/day @ 35.79 MB = 20.9 GB / day**
- **Preprocessing MODIS files at GSFC can reduce WAN traffic and LaRC file handling**

AHWGP Provides Forum for Identification of Algorithm Interface Issues

- **Advantages to Instrument Teams as well as ECS**

Processing Estimates

Instrument Team Inputs to AHWGP Expressed as

- **"Theoretical" Floating_Point_Operations per Execution**
- **Execution Frequency**

Based on Operations Counts or Normalized Benchmarks

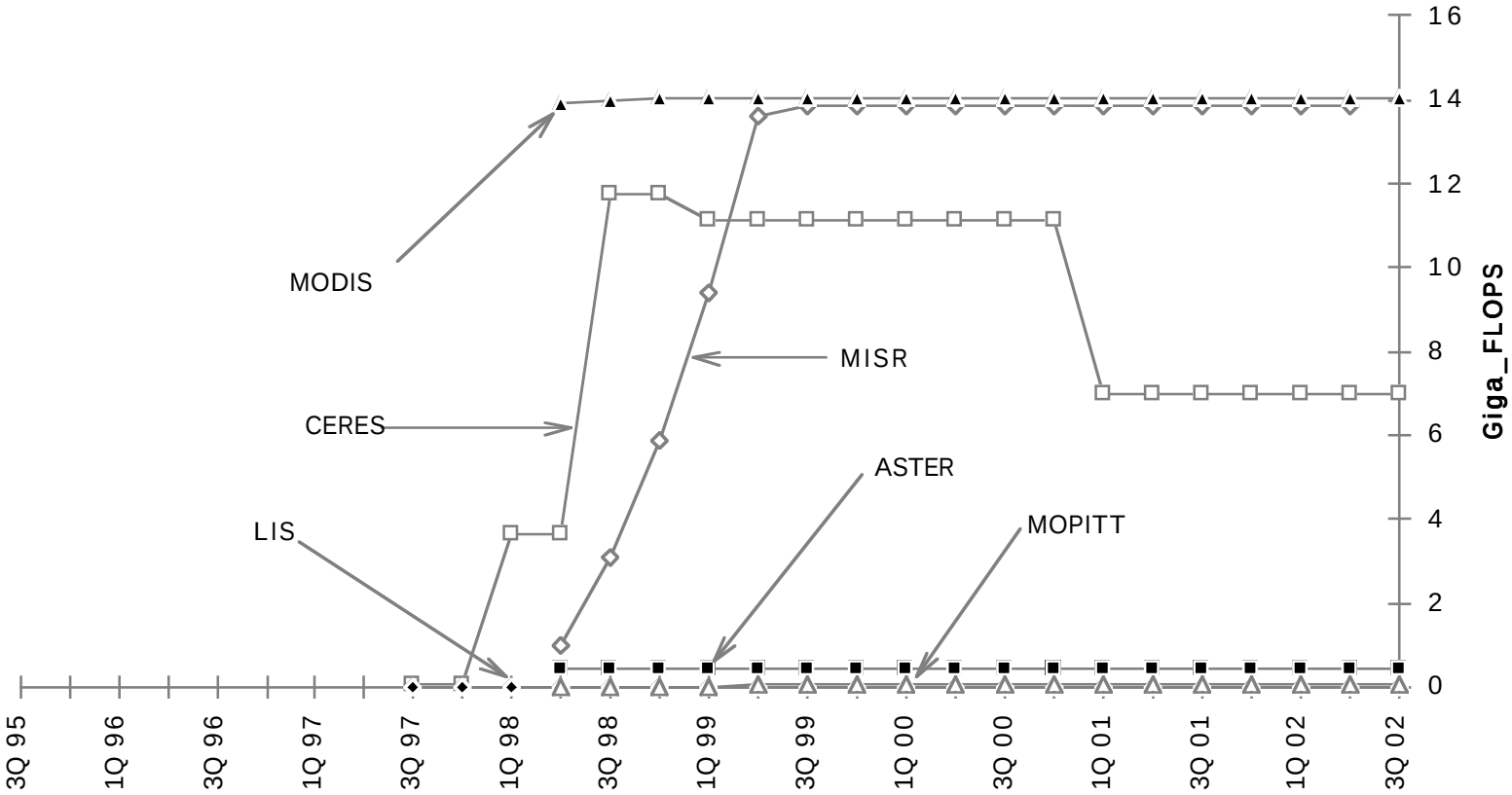
- **Divide by allowed execution time to get "theoretical" FLOPS**
- **Multiply by 4 to get required COTS rating ("peak" FLOPS)**

Technical Baseline Reflects "Theoretical" FLOPS

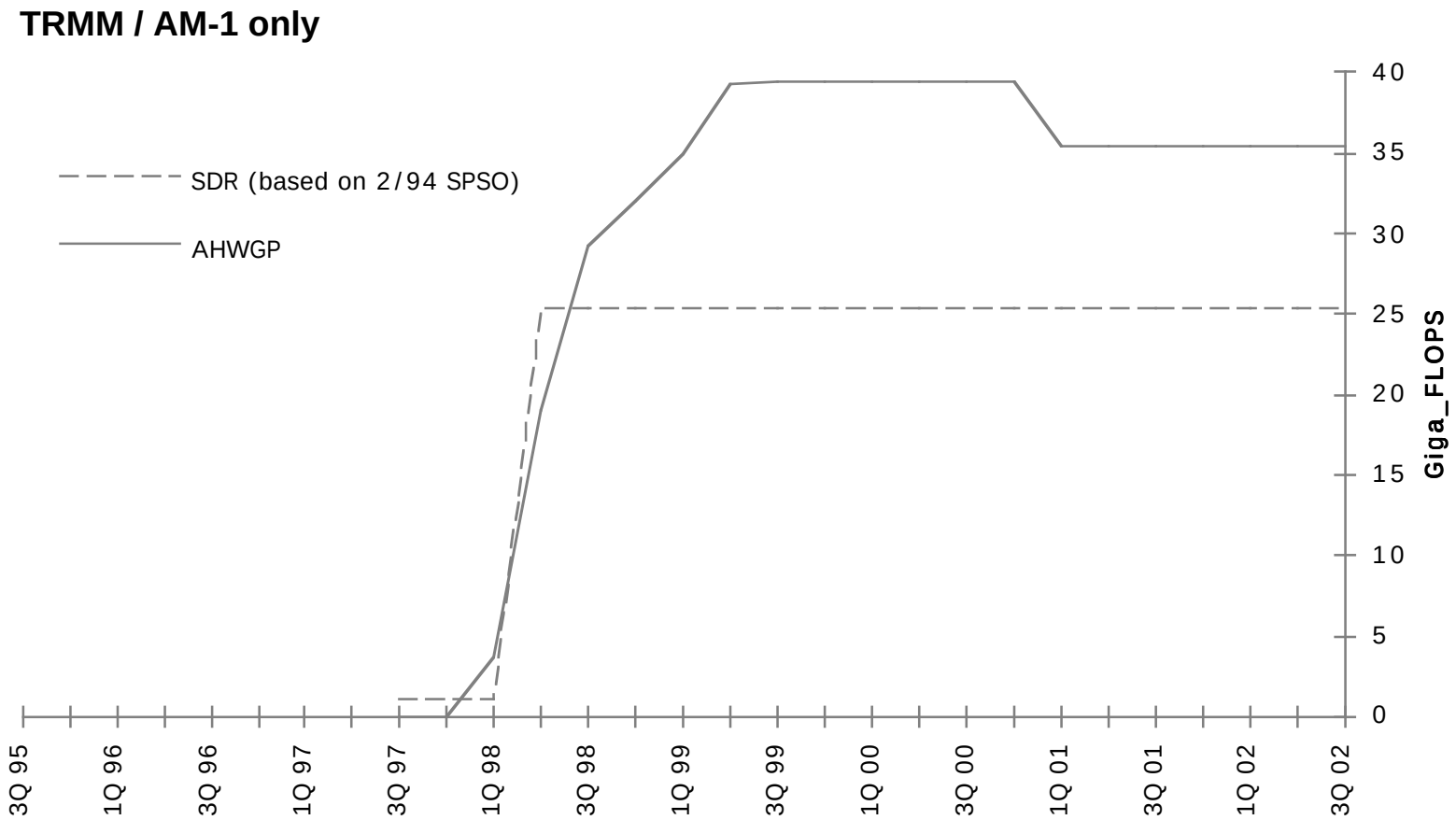
All Graphs in this Presentation Show "Peak" FLOPS

Includes TRMM and AM-1 Instruments Only

Processing by Instrument



Comparison to SDR Baseline



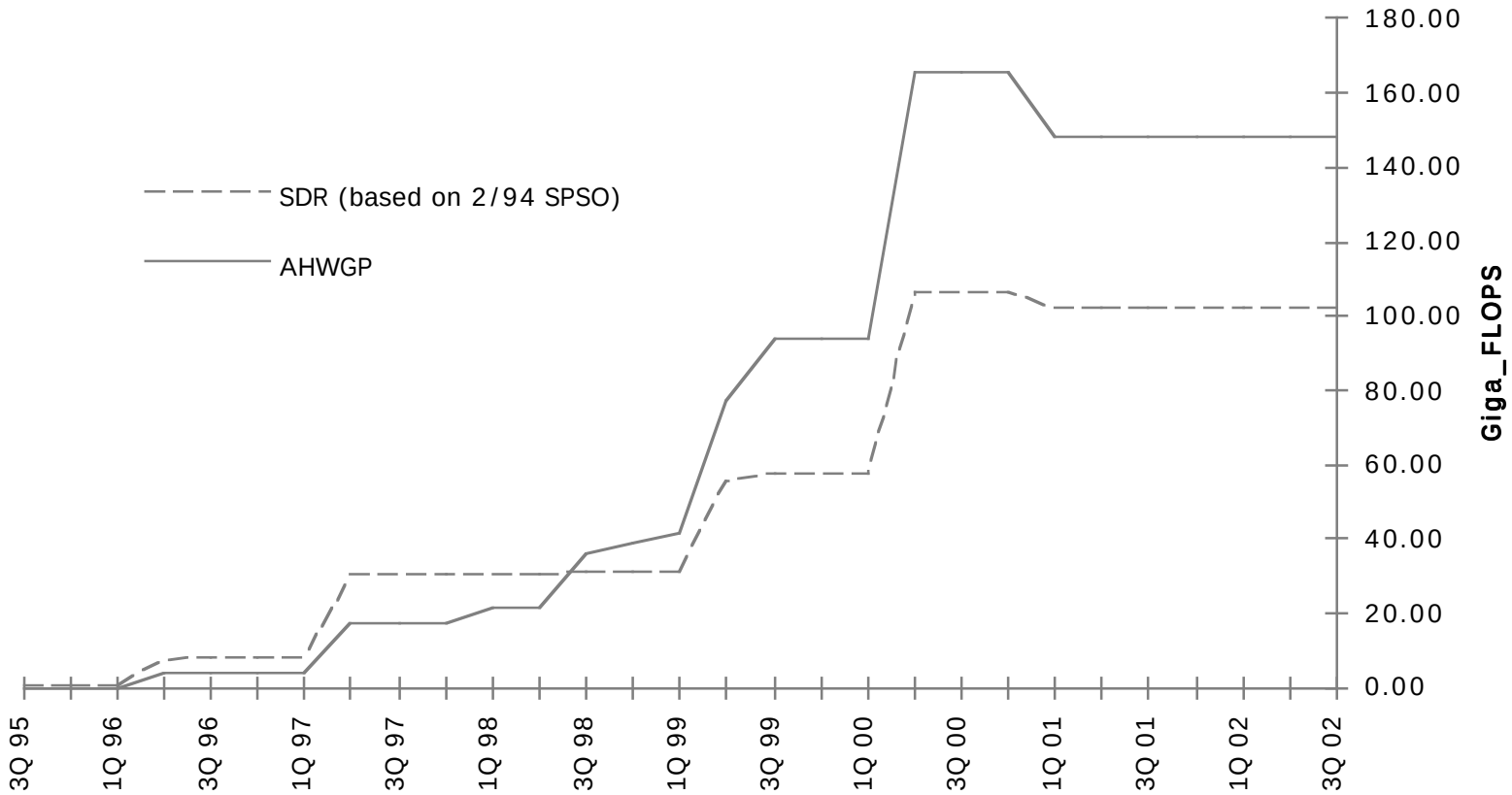
Total Processing Req.

Algorithm Integration & Test Estimate Based on Engineering Judgment
Reprocessing Profile Based on UARS Experience
Total (AI&T + Processing + Reprocessing):

= 0.3 X at L-2 years
= 1.2 X at L-1 year
= 2.2 X at L+1 year
= 4.2 X at L+2 years

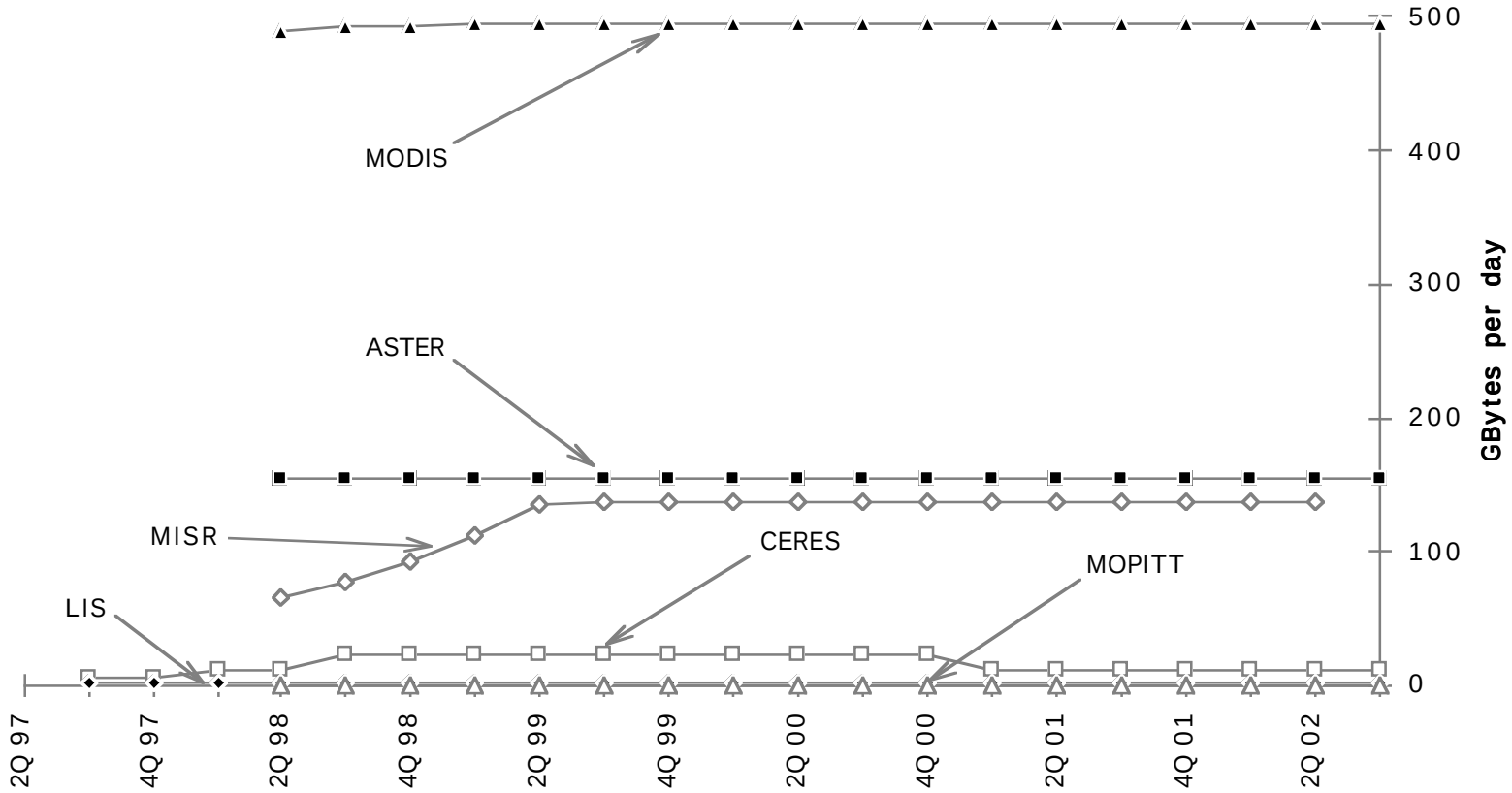
where X = at-launch processing for pre-launch period
X = quarterly processing for post-launch period

TRMM / AM-1 Total



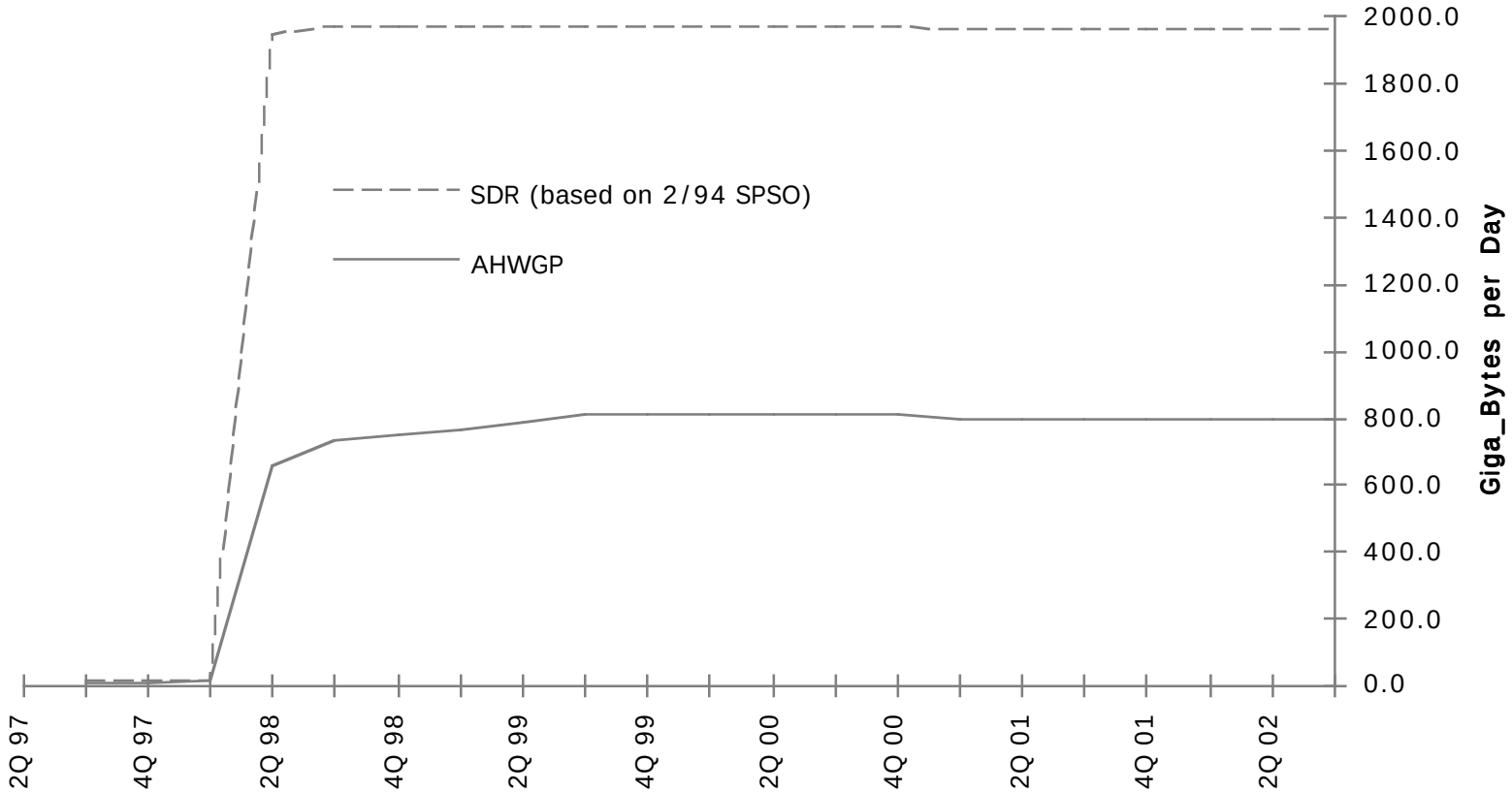
Data Volume by Instrument

Product Levels 1-3

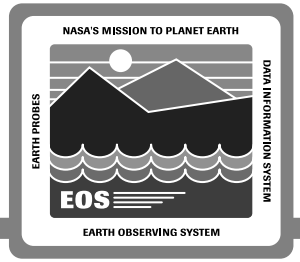


Comparison to SDR Baseline

TRMM / AM-1 only
Product Levels 1-3



Archive Requirements



All Level 1-3 Standard Product Data

6 Months Spare Capacity to Support Reprocessing

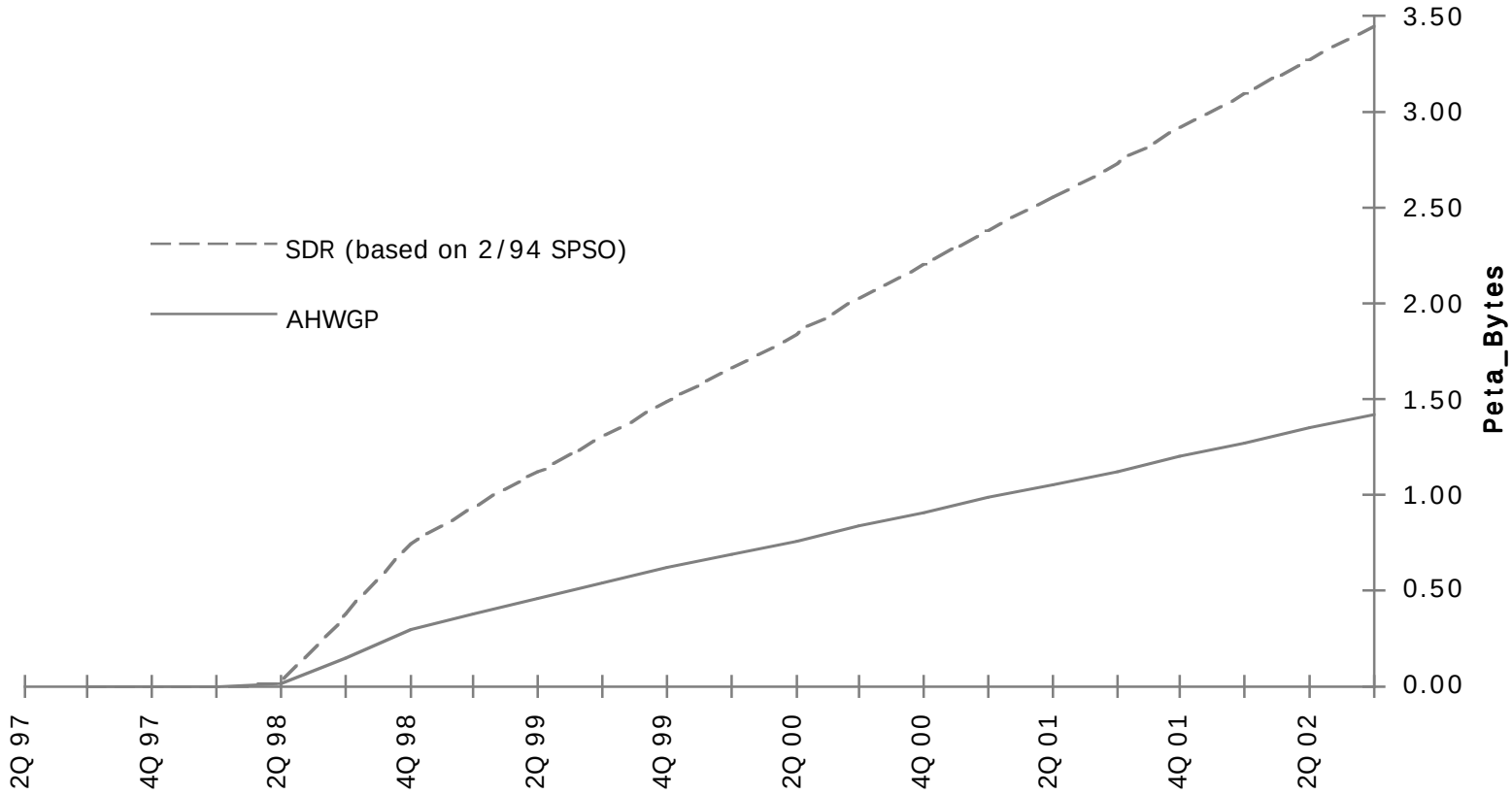
Level 0 Archived if No Level 1A Product (CERES, LIS, MOPITT)

1 Year Rolling Archive for Level 0 (MISR, MODIS)

No Level 0 for ASTER

Product Archives

TRMM / AM-1 only



AHWGP Impact

50% Increase in Estimated Processing Requirement

- **Some New Benchmarking Results**
- **Includes Requested Contingency for ASTER and MISR**
- **Continues Previous Contingency for MODIS**

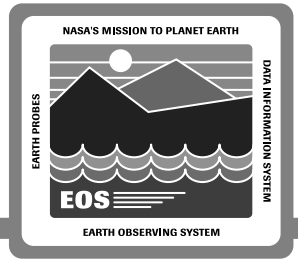
55% Decrease in Estimated Product Archive Requirement

- **Major Savings in MODIS Ocean Products due to File Reorganization**
  - **will require some processing-on-demand or subscriptions to interim products**
- **Other Instruments Have Also Reduced Data Volumes Based on File Definitions**

Reduction in Data Volumes Affects Archives and Working Storage

Estimate 21% Reduction in Cost of COTS HW/SW for TRMM/AM-1 Standard Product Processing and Storage

System Performance Model



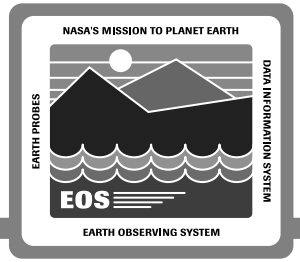
Comparison to SDR Models -

Attribute	SDR	PDR
Purpose	Architecture Trades	Design Trades
Perspective	Product	Process/File
Push/Pull	Separate	Coupled
Language	C	BONeS
Technique	Quasi-Dynamic	Dynamic
Method	Numerical Integration	Discrete Event
Resource Handling	Unconstrained	Constrained

Components in Simulation

	Disk	Processor	IO	Network	Robots	ReadHeads
Ingest	**Y**		**Y**	**Y**	**Y**	**Y**
Data Handler	**Y**		**Y**	**Y**	**Y**	**Y**
Processing	**Y**	**Y**	**Y**	**Y**		
Distribution	**Y**	**Y**	**Y**	**Y**		**Y**

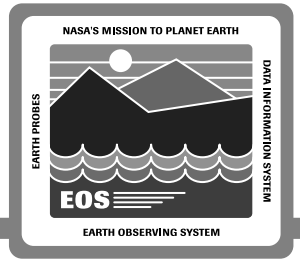
Sample Model Parameters



Data Handler at Each DAAC:

- **Total Archive Disk Pool Size (MB)**
- **Total Number of I/O Channels**
- **Throughput of I/O Channels (MBytes/Second)**
- **Number of Robots**
- **Maximum Robot Movement Time (Seconds)**
- **Number of Read/Write Heads**
- **Maximum Tape Seek Time (Seconds)**
- **Number of I/O Channels for Archive Device**
- **Throughput of Read/Write Heads (MBytes/Second)**
- **Maximum Tape Rewind Time (Seconds)**
- **Number of Transactions into Archive/Data Server/...**
- **Storage Utilization**

Modeling Results



Feedback / Interaction with Instrument Teams (AHWGP)

- **Identified "Orphan" Data Products**
- **Resolved Temporal Disconnects in Coverage of Inputs / Outputs**
- **Revised AHWGP Scenarios for Better Process / File Organization**

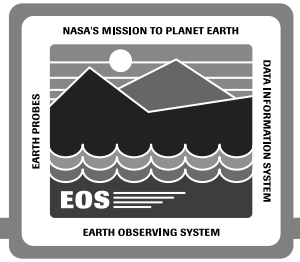
Single-Instrument Models in Validation (except MODIS)

- **Release A Instruments Integrated (CERES and LIS)**

Feedback / Support to Design Teams

- **Scheduling Rules for Standard Products Processing**
- **Improved Understanding of Processing Issues and Push / Pull Interactions**

Next Steps



Improve User Model Data for Relative Interest in Data Products

- **Required for Release B Data Server Sizing (June '95 for IDR)**

Continue AHWGP Collaboration with Instrument Teams

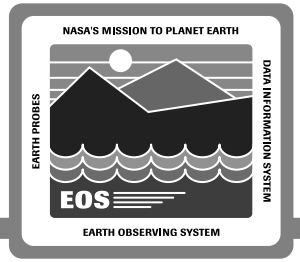
- **Provide Design Feedback to ITs (now for TRMM)**
- **Add post-AM-1 Instruments (ongoing)**

Complete Version 2 of Dynamical System Simulation

- **Design Support for Release B (July '95 for IDR)***
- **Support Trades for Algorithm Teams (through January '96)**

*** Release A does not need dynamical model due to decoupling**

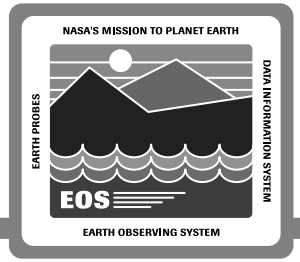
Issues



Address Engineering Boundary Conditions

- **Improve Access to Data with Networks Limitations (July '95 for Rel. B IDR)**
  - **Strategies for precise data identification, subsetting, and incorporation of user methods**
  - **Need IDS participation**
- **Quantify Peak-to-Theoretical FLOPS Ratio (January '96 for Rel. B CDR)**
  - **Instrument Team algorithm benchmarking**
  - **ECS prototyping**
- **Develop QA and Reprocessing Scenarios with AHWGP (June '95 for Rel. A CDR)**
  - **Develop concensus on QA definitions and roles**
  - **Improve understanding of operational implications**
  - **Quantify reprocessing load (incl. DAAC-to-DAAC traffic)**

Issues (cont.)



- **Develop Subsetting / Data Prep Specifications for Instrument Data Dependencies with AHWGP (July '95 for Rel. B IDR)**
  - **Opportunity to reduce data transport and handling costs**
  - **Reduce algorithm integration risks**